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Changing prey abundance as a driver of lion (*Panthera leo*) home range size in Waza National Park, Cameroon

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Chapter 3

ABSTRACT

The spatial ecology of African lions (*Panthera leo*) was studied from 2007 to 2009 in Waza National Park, Cameroon, by equipping seven individuals with GPS/UHF radio-collars. Mean home range estimates using 100% minimum convex polygons (MCP) and 95% kernel-density estimation (KDE) were respectively 1015 km² and 641 km². The lions spent a considerable amount of time outside the park during the study period (21%), resulting in significantly larger wet season home ranges than in the hot dry season when they were largely within the park. Time spent outside of the park coincided with increased livestock predation, especially by males. The seasonal variation observed in home range appeared to be mainly due to prey dispersal, flooding and migrating livestock. Mean home range size was observed to have increased by 58.6% within the last decade. This increase observed in home range was attributed to recent declines in wild prey abundance and may also indicate a trend of general degradation of the park due to intense human pressure. The change observed in the lion’s ranging behaviour was remarkable, with lions crossing the highway parallel to the park to the Cameroon-Nigerian borders. There is an urgent need for measures to restore the integrity of the park, which could include the construction of a fence along the western boundary of the park to prevent lions moving across the parallel highway.

Key words

African lions, GPS tracking, Radio telemetry, Spatial behaviour, Livestock conflict
3.1 Introduction

A home range is the area used by an individual animal species for its regular activities of food gathering, mating and caring for its young (Burt, 1943). Carnivore home range size varies across and within species in relation to a wide range of factors, including body mass, prey availability, social interactions, habitat quality and reproductive status (Gittleman & Harvey, 1982; van Orsdol et al., 1985; Viljoen, 1993; Adams, 2001; Spong, 2002; Hemson, 2003; Bauer & de Iongh, 2005). Abundant food and a high quality habitat allow an animal to meet its biological requirements in a relatively small home range and vice versa (Gittleman & Harvey, 1982; MacDonald, 1983).

The lion is a social cat that lives in family units called prides, consisting of related females and their young accompanied by one or a coalition of related or unrelated adult males (Schaller, 1972; Bygott et al., 1979; Packer et al., 1991). Although pride size varies from 2 to 18 related adult females, most typical prides contain four adult lionesses, their cubs and accompanying males (Schaller, 1972). Lionesses typically defend a permanent home range, which can persist for many generations, with pride males defending these as well during periods of tenure with a pride (Bygott et al., 1979). Large home ranges overlap extensively with those of adjacent prides, while small home ranges tend to have little overlap (Schaller, 1972; van Orsdol et al., 1985). Like other large carnivores at the apex of the trophic level, lions typically occur at relatively low densities and require large areas in which to range.

There are many challenges associated with the conservation of carnivores, including both anthropogenic and ecological factors. Large range requirements associated with negative interactions with humans have led to decline in many of the world’s carnivores. A large carnivore’s home range size is thus a good predictor of its extinction probability relative to the size of the protected areas (Woodroffe & Ginsberg, 1998; Woodroffe, 2001). Large and relatively intact areas for the protection of carnivores are becoming rare. Particularly in West and Central Africa, increased anthropogenic activity as a consequence of rapid human population growth has resulted in a reduction and fragmentation of natural habitats for lions (Nowell & Jackson, 1996; Bauer & Nowell, 2004) and increasing persecution (Tumenta et al. 2010).
Knowing the spatial scale at which ecological processes occur is fundamental to making informed decisions on wildlife management and conservation. To effectively mitigate conflicts between lions and people an improved understanding of the spatial ecology of large carnivores such as the lion is crucial to ensure continued survival of their populations (Marker et al., 2007; Karanth & Chellam, 2009). The spatial ecology of lions has been scarcely studied in West and Central Africa, with the exception of studies in Waza National Park, Cameroon (Bauer & de Iongh, 2005) and in Pendjari Biosphere Reserve, Benin (Sogbohossou, 2011). In contrast, the home range size of the lion is well documented in East Africa, ranging from very small (e.g. 25-51 km² in Nairobi National Park) to relatively large (e.g. 30-400 km² in the Serengeti) (Schaller, 1972; Gittleman & Harvey, 1982; van Orsdol et al., 1985; Schaller, 1972). However in arid and hyper-arid areas of Southern Africa lion home ranges can be as large as 4500 km² in the Kgalagadi Transfrontier Park (Funston, 2011) and 7337 km² in the Kunene Region (Stander, 2006). The variation in home range size between lion populations thus calls for site-specific estimates.

Lion home range size also differs between sexes, which is thought to be a result of differences in body mass between male and female lions (Bauer & de Iongh, 2005), and consequently in energetic needs (Schaller, 1972). Group size and territoriality are social factors that also influence home range size (Packer et al., 2005); with home range size increasing with group size (van Orsdol et al., 1985). Larger prides require more prey and therefore larger areas, depending on prey biomass and prey density.

The most important factor that influences lion home range size, however, is prey abundance (van Orsdol et al., 1985; Bauer & de Iongh, 2005), with lion home range size being negatively correlated with prey abundance (van Orsdol et al., 1985; Bauer & de Iongh, 2005; Loveridge et al., 2009). As there have been drastic declines of natural prey populations in Waza National Park in the last decade (Scholte et al., 2007; de Iongh et al., 2008; Foguekem et al., 2010) we expected that this should have resulted in lion home ranges having increased in size (Bauer & de Iongh, 2005), augmenting the conservation challenges faced by lions there. This study therefore attempted to investigate the drivers of lion home range size in Waza National Park, northern Cameroon, in a region where this important biological parameter was relatively little understood. Furthermore, seasonal and intersexual variations in home range size were investigated to provide data needed for the planning and implementation of conserva-
tion policies and management of protected areas in Waza, and the region as a whole.

3.2 Materials and methods

Study area

The study was conducted in Waza National Park (1,700 km²), situated in the far northern Sudano-Sahelian savannah region of Cameroon. Rainfall in this area is low and irregular between years, with a mean annual rainfall of 600 mm (Beauvilain, 1995). The climate is semi-tropical, with temperatures ranging from 15º C (January mean minimum) to 48º C (April mean maximum). The area has three characteristic seasons: a wet season, from June to October; a cold dry season, from November to February; and a hot dry season, from March to May. A floodplain of the Logone River comprises 42% of the parks surface area and is seasonally inundated with water and dominated by heavy cracking clay soils (vertisols), and coarse grasses. The other habitats in the park include two woodland vegetation zones dominated by *Acacia spp* and *Sclerocarya birrea*. Key lion prey species occurring in the park in order of importance in the lion’s diet are Buffon’s kob (*Kobus kob kob*), topi (*Damaliscus korrigum*), roan antelope (*Hippotragus equinus*), red fronted gazelle (*Gazella rufifrons*), warthog (*Phacochoerus africanus*) and giraffe (*Giraffa camelopardalis*) (Tumenta et al., in review).

Lion sedation and collaring

Seven lions were immobilized and radio-collared between 2007 and 2009, four of these with GPS-PLUS download collars (from VECTRONICS Aerospace) and three with African Wildlife Tracking (AWT) GPS GSM collars. Only one of the AWT collars fitted to female lion L5 worked during the study period. The Vectronic collars were fitted to males L1 and L2 and lionesses L3 and L4. Table 3.1 presents details of the researched lions. The lions were captured by free darting after being attracted using a calling station set-up adapted from Ogutu and Dublin (1998). For the collaring protocol, the same procedure was used as Bauer and de Iongh (2005).
Table 3.1  **Lions sedated and collared in Waza National Park, Cameroon in 2007-2008**

<table>
<thead>
<tr>
<th></th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>L5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Adam</td>
<td>Jean Pierre</td>
<td>Fanne</td>
<td>Elizabeth</td>
<td>Rossie</td>
</tr>
<tr>
<td>Sex</td>
<td>Male</td>
<td>Male</td>
<td>Female</td>
<td>Female</td>
<td>Female</td>
</tr>
<tr>
<td>Body weight</td>
<td>160 ± 5 kg</td>
<td>186 kg</td>
<td>110 kg</td>
<td>103 kg</td>
<td>96 kg</td>
</tr>
<tr>
<td>Habitat</td>
<td>Woodland</td>
<td>Floodplain</td>
<td>Floodplain</td>
<td>Floodplain</td>
<td>Woodland</td>
</tr>
<tr>
<td>Start date</td>
<td>10-05-07</td>
<td>05-05-07</td>
<td>06-05-07</td>
<td>05-05-07</td>
<td>18-05-08</td>
</tr>
<tr>
<td>End date</td>
<td>04-04-08</td>
<td>18-11-07</td>
<td>25-09-07</td>
<td>12-06-09</td>
<td>01-02-09</td>
</tr>
<tr>
<td>Study period</td>
<td>±11 Months</td>
<td>± 7 Months</td>
<td>± 5 Months</td>
<td>± 23 Months</td>
<td>± 8 Months</td>
</tr>
<tr>
<td>Number of fixes</td>
<td>14883(1856)*</td>
<td>8740(1069)*</td>
<td>6620(822)*</td>
<td>34902(4378)*</td>
<td>1306*</td>
</tr>
</tbody>
</table>

*Four-hour selection of GPS location fixes for home range calculations, L1-L5= Lion number

**Lion tracking**

After collaring, the lions were closely monitored in the field from 2007 to 2009 through radio telemetry. Tracking was done from a four-wheel-drive vehicle using a VHF-radio transmitter following the methods described by Bauer (2003). The reception range of the transmitter was about 4 km at ground level and about 15 km from the top of the highest inselberg in the park. The GPS unit in the collars recorded at scheduled intervals of 30 min a fix of GPS coordinates and the local temperature. When a signal was obtained from any of the lions with a VHF receiver, communication was then established between a handheld UHF terminal and the collar to obtain the most recent location fixes. The last GPS location fix of the lion was then put into a hand held GPS unit to track down the lion for observation.

**Data analysis**

The data were imported into Arcview 3.2 GIS (ESRI 1992) for analyses using the extension packages Spatial Analyst and Animal Movement (Hooge & Eichenlaub, 2000). Home range sizes of lions were calculated using Minimum Convex Polygon (MCP) (Bauer & de Iongh, 2005; Marker et al., 2008; Jhala et al., 2009) and the Fixed Kernel (Marker et al., 2008; Jhala et al., 2009) methods for the entire data set during one year of the study. Home ranges for the different seasons were calculated using the Fixed Kernel method, with the 100% MCP presented for comparison with earlier and other studies. A large number of fixes was obtained for the
entire data set with 48 data points per day. To facilitate analysis and reduce the probability of autocorrelation, a 4-hour selection was carried out on the data, reducing the data size to 6 points per day. The Fixed Kernel test was used to calculate home range metrics; the outer boundary set at 95%, the core area 50% and hotspots 5% (White & Garrot, 1990). The smoothing factor was chosen using the Least Square Cross Validation (LSCV) procedure (Kernohan et al., 2001) and was 0.02 for all calculations. Differences in mean home range size between season and sex were calculated with t-test in the SAS software. A one-sample t-test was performed to compare the mean MCP of this study with that reported by Bauer & de Iongh (2005).

3.3 Results

Home range

The collar fitted on lioness L3 became dysfunctional 5 months after it was attached. Lions L1, L2 and Lioness L5 were killed 11, 7 and 8 months after collaring, respectively (De Iongh et al., 2009; Tumenta et al., 2010). Lioness L4 provided data for the entire two-year study period. However, all the lions provided more than the required minimum number (60) of fixes for home range estimation (Spong, 2002). Data from all the lions covered the different seasons of the year except for lioness L3, which had no data for the cold dry season. For comparison with a previous study in Waza National Park on lion home range (Bauer & De Iongh, 2005), only one year’s data from four lions collared at the same time was analysed.

Four lions (L1-L4) collared in 2007 provided sufficient fixes for home range size estimations, which varied from 307 km\(^2\) to 1384 km\(^2\) (mean 1015 km\(^2\)) using the Minimum Convex Polygon (MCP) method (Figure 3.1). L5 had no data during 2007 and was excluded from the total home range calculations. By comparison the mean for the 95% Fixed Kernel home range estimates was 641 km\(^2\) (Table 3.2).
Figure 3.1 Minimum convex polygon (100%) home range estimates of four radio-collared lions in Waza National Park, Cameroon in 2007-2008

Table 3.2 Home range (km²) estimates of four radio-collared lions in Waza National Park, Cameroon in 2007-2008

<table>
<thead>
<tr>
<th>Lion ID</th>
<th>MCP 100 All data</th>
<th>95% Ker All data</th>
<th>50% Ker All data</th>
<th>5% Ker All Data</th>
<th>Cold dry season*</th>
<th>Hot dry season*</th>
<th>Wet season*</th>
<th>Group size</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>1384.4</td>
<td>799.8</td>
<td>26.4</td>
<td>1.7</td>
<td>421.9</td>
<td>127.7</td>
<td>874.4</td>
<td>4</td>
</tr>
<tr>
<td>L2</td>
<td>1148.7</td>
<td>734.5</td>
<td>98.7</td>
<td>2.9</td>
<td>348.4</td>
<td>90.2</td>
<td>685.1</td>
<td>2</td>
</tr>
<tr>
<td>L3</td>
<td>307.1</td>
<td>246.9</td>
<td>80.4</td>
<td>2.8</td>
<td>–</td>
<td>107.2</td>
<td>259.9</td>
<td>1</td>
</tr>
<tr>
<td>L4</td>
<td>1220.8</td>
<td>780.7</td>
<td>66.4</td>
<td>1.9</td>
<td>505.9</td>
<td>200.7</td>
<td>359.5</td>
<td>–</td>
</tr>
<tr>
<td>Average</td>
<td>1015.2</td>
<td>640.5</td>
<td>68.0</td>
<td>2.3</td>
<td>425.4</td>
<td>131.5</td>
<td>544.7</td>
<td>–</td>
</tr>
</tbody>
</table>

*95% Fixed Kernel estimates; L1 & L2 were male lions; L3 & L4 were female lions
Lions had significantly larger mean home ranges during the wet season (545 km², SD= 285.1) compared to the hot dry season (132 km², SD= 77.2) (F=5.65, P=0.04, df=2, 3). The home ranges of males were observed to be 65.8% larger than those of females according to the Minimum Convex Polygon estimation (mean MCP 1267 km², SD= 166.7 vs. 764 km², SD= 646.1). However this difference was not significant. Male and female lions showed a difference in home range size across the different seasons, with both sexes having their smallest home range during the hot dry season. The males had the largest home range (mean 780 km²) during the wet season, whilst the home ranges of the females were largest during the cold dry season (mean 506 km²). A comparison of the mean MCP home range of this study (1015 km²) with the mean MCP home range in 2000 (640 km²) showed no significant difference. The mean home range of this study, however, was 58.6% larger than the mean home range recorded in 2000.

The Kernel contour home range of collared lions varied markedly during the year and especially during the three seasons (Figure 3.2a-d). These figures show that the home ranges of all of the lions were completely within the park during the hot dry season, with core areas and hotspots (50% and 5% kernel home ranges) located at water holes retaining water during the dry months of the year. The core areas for lions in the floodplain zone of the park shifted to the Acacia and woodland zones during the wet season and for male lions were located outside the park during the cold dry season. Lions in the woodland zone of the park had home ranges (L1=1384 km²) comparable to lions in the floodplain zone of the park (L2=1022 km² and L4= 1220 km²). Overall, most of the GPS location fixes (56%) of the lions were located in the floodplain vegetation zone of the park, 22% in the Acacia vegetation zone and 22% in the woodland vegetation zone (Table 3.3).
Figure 3.2a Kernel home ranges of four radio-collared lions in Waza National Park
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Figure 3.2b  Kernel home range of two lions and one lioness in Waza National Park in the cold dry season
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Figure 3.2c  Kernel home ranges of four radio-collared lions in Waza National Park in the hot dry season
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Figure 3.2d Kernel home ranges of radio-collared lions in Waza National Park in the wet season
Table 3.3 Percentage of GPS location fixes indicating presence of lions in different vegetation zones of Waza National Park, Cameroon in 2007-2008

<table>
<thead>
<tr>
<th>LION</th>
<th>Woodland</th>
<th>Acacia</th>
<th>Floodplain</th>
<th>Inside park</th>
<th>Outside park</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>75.1</td>
<td>22.9</td>
<td>1.9</td>
<td>68.7</td>
<td>29.0</td>
</tr>
<tr>
<td>L2</td>
<td>9.3</td>
<td>27.2</td>
<td>63.5</td>
<td>79.1</td>
<td>20.8</td>
</tr>
<tr>
<td>L3</td>
<td>4.1</td>
<td>37.7</td>
<td>58.2</td>
<td>100.00</td>
<td>–</td>
</tr>
<tr>
<td>L4</td>
<td>0.0</td>
<td>12.6</td>
<td>87.4</td>
<td>86.1</td>
<td>13.6</td>
</tr>
<tr>
<td>All lions</td>
<td>22.1</td>
<td>22.1</td>
<td>55.9</td>
<td>79.1</td>
<td>20.7</td>
</tr>
</tbody>
</table>

Crucially, 21% of the GPS fixes were located outside the park (Table 3.3), with lions spending most time outside park during the cold dry season (57% of fixes), less during the wet season (39%), and the least during the hot dry season (7%). Overall, males spent more time outside the park (25%) than females (14%). Three of the four collared lions appeared to have home ranges that overlapped considerably with human land use, including settlements, farmland and cattle routes (Figure 3.1). Lioness L3 did not leave the park limits.

Social structure

The group size excluding cubs <2 years old of radio-collared lions varied from 1 to 4. Based on sightings during the study period, the mean group size of lions in the entire park was 1.6 (n=21 sightings). The male: female ratio was 1:3 and percentage of cubs was 22% (n=21). The 100% MCP home range of the collared lions overlapped extensively in the central part of the park (Figure 3.1). The 50% fixed kernel home range core areas of lion L2 and lioness L4 were located at the same water hole in the floodplain vegetation zone of the park, indicating that they belonged to the same group. Lions L1 and lionesses L3 and L5 had their core areas located at different water holes in the park. The five radio-collared lions belonged to four different lion groups in the park.

3.4 Discussion

The home range estimate of this study (mean 1015 km²) is an increase of 58.6% over the previous estimate (630 km²) recorded in 2000 by Bauer & De Iongh (2005). Statistical analysis did not provide any significant difference for the means. However, this could be attributed to the high standard deviation observed in our data, which was the effect of an in-
fluential outlier. When the outlier was dropped from the analysis, mean MCP for this study was significantly larger (P<0.05) than that reported in 2000. Thus as predicted by the prey abundance relationship (van Ors-dol et al., 1985), lions in Waza National Park during our study had larger home ranges as a reflection of the decline in prey abundance. Also when compared with home range data from studies in West and Central Africa for lions in Pendjari NP, Benin (Sogbohossou, 2011), lions in Zakouma NP, Chad (Vanherle, 2005), and lions in Bénoué NP in Cameroon (Schoe, 2007), Waza NP home ranges were observed to be larger than in any of these studies. In Pendjari NP, Benin (West Africa) which has a prey biomass of 615-1665 kg/km², the average home range size of lionesses was 256 km² (Sogbohossou, 2011) compared to the 764 km² in this study, where the prey biomass was 142 kg/km². This clearly reflects increases in home range size in response to decline in prey abundance. The home ranges of lions in Waza National Park were observed to be larger than those reported for lions in East Africa as well (Gittleman & Harvey, 1982; Schaller, 1972), but similar to home range sizes in the arid and semi-arid parts of Southern Africa (e.g. Etosha National Park, Namibia ≈ 600 km², Stander, 1991). They were, however, smaller than the home ranges of lions in the arid southern Kalahari (≈ 2823 km², Funston, 2011) and the hyper-arid Kunene area (≈ 7337 km², Stander, 2006).

We are confident that the difference observed in home range size for lions in Waza National Park between this study, and the study of Bauer & de Iongh (2005), was due to the dramatic decline in prey populations reported within the last decade (Scholte, 2007; Foguekem et al., 2010). During this period, prey biomass declined from ≈ 800 kg km² in 2000 (Bauer & de Iongh, 2005), to 632 kg km² in 2005 (de Iongh et al., 2008; Bauer et al., 2008), and then to as low as 142 kg km² in 2007 (Foguekem et al., 2010). Furthermore, this may explain recent increases in the levels of livestock depredation. In 2001, Bauer (2003) found that livestock comprised 10% the diet of lions in Waza National Park, but this has now increased to 22% (Tumenta et al., in review). In conclusion, these findings add further support to the assertion that the home range size of lions is driven by an inverse relationship with prey abundance (van Ors Dol et al., 1985; Bauer & de Iongh, 2005; Loveridge et al., 2009). In effect, therefore, the carrying capacity for lions in Waza National Park has declined substantially within the last decade, as home range size is known to correlate directly with lion abundance in a specific area (Hemson, 2003).
Similar to the findings of Bauer & de Iongh (2005), the home ranges of male lions were observed to be larger than those of females, supporting the intersexual differences in body mass. The intersexual difference in home range could also be driven by the fact that female ranging behaviour is correlated with the distribution of resources, whereas that of males in addition to the distribution of resources is associated with the distribution of females (Loveridge et al., 2009).

Although a majority of the GPS location fixes of the lions within the park were recorded in the floodplain vegetation zone, one cannot conclude that this zone was the most important for lions; this could have been more related to the fact that the floodplain vegetation zone makes up the largest proportion of the park. Lions in the floodplain where observed to shift their core areas to the Acacia and Woodland zones in the wet season. This was not only because of shifts in prey distribution, but also because of the inundation of the floodplain zone during the wet and part of the cold dry seasons. However, during the hot dry season, water is the primary limiting factor for ungulate (prey) populations within the park. This means that ungulates congregate at waterholes, briefly creating locally high prey densities, resulting in lions having their smallest home ranges at this time of year. On the other hand, in the wet season water becomes available everywhere allowing prey to disperse within the entire park. The resulting prey scarcity within the park causes lions to range more widely and to move outside of the park in search of prey, thus extending their home range. These patterns are similar to those described by Bauer & de Iongh (2005), but the extent of the wet season dispersal has increased over the last decade and now also includes ranging across the highway parallel to the western limit of the park.

Another possible explanation for lions ranging furthest from the park boundaries in the wet season is related to livestock management. In the hot dry season, wild prey congregate at waterholes within the park whereas livestock, especially cattle, are present in high concentrations just out of the park boundaries and make intrusions into the park to water. When the rains come, the pastoralists move their herds south of the park area, to locations where they spend the wet season. Due to the lion’s dependence on livestock as prey (Tumenta et al., in review), they may follow the pastoralists and their cattle away from the park to their wet season sites. This was alluded to in the wet season of 2007, when villagers in Dogba 45 km from the park boundaries attested that lions were
present in their area only when nomadic pastoralists arrived with their cattle (van Berkel, 2007).

Both males made excursions out of the park, including a distance of 12 km from the park border for lion L1, and up to 27 km for lion L2. Both males had their core area outside of the park during the cold dry season. Lion L1 occupied an area at the Cameroon-Nigeria national boundary, which was open to a higher risk of persecution. This behaviour could render the lions even more vulnerable to persecution and retaliatory killings. Border crossing by lions from Amboseli, Kenya to Tanzania has also been reported after the 2009 drought that caused prey populations to decline in Amboseli (Visser, 2010). Lioness L4 also ventured out of Waza National Park in 2007, moving a distance of 17 km away from the park. During 2008, however, this lioness remained within the park, as did lioness L5. There were reports confirmed by this research of lion presence and attacks on livestock as far as 45 km from the park during the wet season (van Berkel, 2007). Bauer & de Iongh (2005) also observed individual differences regarding lion ranging and livestock depredation. The male lion Hamidou was a habitual problem animal, spending most of his time outside the park and feeding primarily on livestock. One female, in contrast, never left the park and was not observed taking livestock. The other collared lions periodically left the park, where they presumably killed livestock. It is clear that lion-livestock conflicts are serious in the areas surrounding Waza National Park. The local population ranked depredation a priority problem (Bauer, 2003). However, locals do not seem to make much effort to solve the problem and attacks do at times result in retaliatory killing (de Iongh et al., 2009; Tumenta et al., 2010). Nonetheless, when one considers that 22% of the lions’ diet comes from livestock (Tumenta et al., in review), people do indeed show remarkable levels of tolerance.

Although the lion population in the park has declined to between 14-21 individuals (Tumenta et al., 2010), the average group size of lions did not change in the last decade. This rule out the presumption that the home range size of lions might have increased as a consequence of an increase in lion group size (van Orsdol et al., 1985; Packer et al., 2005). The lion group size of 1.6 observed in this study is similar to 1.5-1.6 reported by Bauer et al. (2003), as was the overall male to female ratio of 1:3. It is interesting to note that lion populations in West and Central Africa generally have about the same average group size, typically below three individuals (Bauer et al., 2003).
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The larger home ranges observed in this study is another indication that the state of the wildlife populations in Waza National Park is in sharp decline, with ungulate (prey) populations deteriorating due to ineffective park protection and management. To restore the populations of the prey species and that of lions, a concerted effort will be needed to implement measures to reverse the existing trends. In particular, the lions need to be prevented from crossing the highway and ranging to bordering Nigeria. A solution may be found in the construction of a partial fence along the western limit of the park. Such a fence would probably considerably reduce the area needed to be surveyed by park staff, concentrating efforts and scarce finances to a more limited area. Management should enforce temporal mapping of pastoral activities around the park base on the seasonal ranging behaviour of the lion.

Acknowledgements

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References

Changing prey abundance as a driver of lion home range size


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Chapter 3


